

Application of On-line Corrosion Monitoring Technology

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Abstract

This article summarized the history and current situation of online corrosion monitoring technology and focused on explaining the online corrosion monitoring techniques commonly, such as electrochemical detection, resistance probe monitoring, monitoring inductance probe and pH probe monitoring. Each online corrosion monitoring technology has its advantages and disadvantages in different corrosive media and equipment. According to a different situation, not only choose a single online monitoring technique, but also be integrated use of various online monitoring techniques, to increase the sensitivity of online corrosion monitoring. This article describes the application in online corrosion monitoring technology in various devices. For example applications in the oil refining device; application of circulating cooling water system; in the application field of the surface production system; application of atmospheric and vacuum distillation unit; in the high-sulfur natural gas purification plant application; application in catalytic cracking unit and application of ocean platform. Online corrosion monitoring technology can achieve the expected results. The future development of line corrosion monitoring technology made some prospects.

Keywords

Corrosion; On-line Monitoring; Detection Method; Monitoring Technology.

1. Introduction

According to corrosion factors, corrosion monitoring technology is divided: online and off corrosion monitoring techniques. Online corrosion monitoring technology mainly using an electrochemical probe, the probe resistance, inductance probe, hydrogen probes, electrochemical noise, and other methods need to be monitored to monitor the corrosion process. Offline corrosion monitoring technology mainly using ultrasonic thickness measurement points, coupons, corrosion inspection, corrosion product analysis, and other objects that need to be monitored for corrosion monitoring results. Offline corrosion monitoring technology has a long cycle, low efficiency, large errors and other issues, while online corrosion monitoring technology compensates for the lack of off-line detection technology, it can enable accurate detection of the corrosion process.

2. Research Progress

Corrosion detection technology was developed by the laboratory corrosion test methods and factory equipment NDT technology development, which is an urgent need for industrial production, especially petrochemical enterprise production environments need to solve this problem [1-2].

According to the survey of developed countries, annual losses due to corrosion caused by roughly two percent GDP , at the same time, the world's annual production of steel, of which ten percent is consumed due to corrosion. Since the 1980s, Corrosion Association International have a clear understanding of corrosion monitoring technology, adopt techniques to monitor

the corrosion process, the purpose is to slow corrosion. For example, American Contest and Metal Samples Company specialize in corrosion monitoring product development and marketing companies. The main products are linear polarization corrosion measurement instrument, corrosion resistance probe meter, hydrogen permeation monitor, and Microco corrosion monitor. United States, Britain, and other petrochemical companies started to develop a variety of corrosion monitoring techniques used in water treatment, oil refining, pipeline monitoring, corrosion inhibitors [3].

Table 1. Common online corrosion detection technology parameters

Monitoring method	Applicable medium	Operating conditions	Sensitivity	Probe price (RMB)	Reference position	Main manufacturers
Electrochemical monitoring	Aqueous electrolyte	Low-pressure probe: use temperature is not more than 200 °C, the pressure is not greater than 2 MPa. High-pressure probe: use temperature is not more than 100 °C, the pressure is not more than 20 MPa;	5%	2500	Circulating water pipeline, oil field sewage	Chinese Academy of Sciences Institute of metal ; Honeywell company
Resistance probe monitoring	Any medium (oil/gas)	(1) the low-temperature resistance, the temperature is not more than 230 °C, the pressure is not greater than 2.5 MPa, can tear open outfit is its connection with pressure, pipeline diameter should not less than 150 mm if the front belt hanging piece is 219 mm. The smaller pipe diameter shall not be monitoring the corrosion trend. (2) : high-temperature resistance probe temperature is not more than 400 °C, the pressure is not greater than 2.5 MPa, the connection method for flange connection and tear open outfit, with pressure pipeline diameter should not less than 150 mm, if the front with bolt diameter should not less than 219 mm, evaluation when select material used. (3) the low-temperature high-pressure resistance probe: using temperature is not more than 100 °C, the pressure is not more than 20 MPa, the connection method with flange connection without disassembling and flange connection can take to tear open outfit two kinds of pressure, process pipeline shall not be less than 150 mm in diameter, if the front with bolt diameter shall not be less than 219 mm, the material selection of more serious corrosion parts of the oil.	0.1~1 μ m	3500~6500	Atmospheric and vacuum heat pipe	Chinese Academy of Sciences Institute of metal; Yi Anda company
Inductance probe monitoring	Any medium (oil/gas)	(1)low-temperature tubular inductance probe: using temperature is not more than 230°C, the pressure is not greater than 2.5 MPa, installation is under pressure to tear open outfit, process pipeline diameter should not less than 100 mm, if the front with the diameter of not less than 159 mm. The guidance note agent. (2) low-temperature sheet inductance probe: using temperature is not more than 120 °C, the pressure is not more than 10 MPa, installation is under pressure to tear open outfit, process pipeline diameter not less than 50 mm. The guidance note agent used. (3) the high-temperature tube inductance probe: using temperature is not more than 450 °C, the pressure is not greater than 2.5 MPa, disassembling connection methods have flanged connections and bring pressure two kinds, process pipeline diameter should not less than 100 mm, if the front with bolt diameter shall not be less than 159 mm. Guidance note agent	10~50 nm	4500~8500	Crude distillation, catalytic cracking, and hydrocracking, circulating water yards	Metal research institute, Chinese academy of sciences, the RCS, Yi Anda company
PH probe monitoring	water	Temperature is not more than 70 °C, the pressure is not greater than 0.4 MPa	pH=0.2	4500	Crude distillation tower reflux tank sewage pipe	Chinese Academy of Sciences Institute of metal ; Honeywell company

After 1998, in the field of corrosion monitoring also appeared many new technologies in China. For example, the CAS Institute of Metals and SINOPEC Gaoqiao Branch and other units jointly developed the technology of high-temperature resistance probe. High-temperature resistance probe technology is online monitoring more than 260°C high-temperature corrosion. In the same year, High-temperature resistance probe technology through the identification of SINOPEC, and the use of the in petrochemical enterprises. CAS Institute of Metals' inductive probe techniques developed to fill the gap, making domestic corrosion monitoring technology has reached the international advanced level, in 2005. Then, line corrosion monitoring technology has been further developed for the enterprise network and the Internet monitoring system that allows management and exchange of data more convenient. Due to the development of these technologies, so that our corrosion monitoring technology into the international advanced level, some reached the international advanced level [3].

Table 2. Corrosion monitoring technology choice

Systems	Approach	Numbers
Crude oil system	corrosion coupon, resistance probe and inductance probe, sampling, biological probe	3
Gas system	corrosion coupon, resistance probe, and inductance probe	2
Production water system	corrosion coupon, sampling, linear polarization resistance probe, probe, inductance probe	2
Water injection system	corrosion coupon, linear polarization resistance probe, sampling, and biological probe, inductance probe	3
Closed drainage system	corrosion coupon, linear polarization probe, inductance probe	2

3. The Main Technique

Currently, the common online corrosion monitoring technology is mainly four: electrochemical monitoring, resistance probe monitoring, inductance probe monitoring and pH probe monitoring.

3.1 Electrochemical Monitoring

Electrochemical monitoring [4] is performed by measuring the corrosion rate, current indicators are determined standard corrosion rate. The advantage of this monitoring method is a shorter and faster cycle. However, the monitoring process is a restricted environment, electrochemical monitoring must be in the water.

3.2 Resistance Probe Monitoring

A resistance probe is measured through on-line wire corrosion thinning, and temperature compensated to eliminate the effect of metal temperature coefficient. This monitoring technology is widely used in a variety of conditions and media. However, due to the long measurement period, low sensitivity, resulting in not recording the corrosion rate of transient changes [5].

3.3 Inductance Probe Monitoring

Inductance probe monitoring is an effective method of the indirect corrosion monitoring device. Inductance probe to detect metal corrosion loss is measured as the basis, by measuring the AC signal change caused by corrosion thinning corrosion test piece to calculate the rate of corrosion loss. By placement in the pipeline measuring element, after the test strip corrosion, the cross-sectional area becomes smaller, the AC signal is changed, the AC signal is applied to

the test strip to measure, to calculate the number of components measuring thinning and corrosion rate by varying the AC signal [6].

Inductance monitoring probe is measured resolution of 30nm. Since the measurement signal using an AC signal, The advantage of this technique is to anti-interference ability and high accuracy. It is currently a more popular online monitoring method.

3.4 pH Probe Monitoring

The pH probe monitoring is the use of H^+ sensitivity, on the electrode to measure the pH of the medium. Each line monitoring techniques have their advantages and limitations, detailed comparison sees Table 1. So if you want accurate measurement and control of the site, you need to use a variety of techniques to form a comprehensive online monitoring system.

In addition to Table 1, line monitoring technology, this article describes several other online monitoring, which is linearly polarized probe and the biological probe.

The principle of linear polarization probe is an electrochemical Stren and Geary law, which is a linear relationship between the change in corrosion potential close to in current and potential changes, and the slope is inversely proportional to the corrosion rate. The advantage is to measure speed, instantaneous corrosion rate measured directly, quickly reflect changes in equipment operating conditions, high sensitivity, data and intuitive. Weaknesses: Only for the electrolyte solution. Therefore linear polarization probing technology is mainly used on water systems.

Biological probe mainly used to collect bacterial samples, it applies to the crude oil system. There are anaerobic bacteria sulfate-reducing bacteria in the crude oil system. SRB is a depolarizing agent, accelerated corrosion of the pipe. The biological probe is to recognize SRB. To monitor the site for a specific device, media should consider various factors, using one or two effective online corrosion monitoring technology, you can select the specific reference to Table 2. Table 2 is probably a reference standard, face to different situations problems, it should be done to analyze specific issues.

4. The Application of on-Line Corrosion Monitoring Technology

4.1 In the Application of the Refining Units

Online corrosion monitoring in refinery production role [8] is: To evaluate the effect of injection agent, guiding injection agent process; guidance crude oil mixing; automatic control NOTE agent; maintenance monitoring with sentinel combined thickness measurement guidance.

Line corrosion monitoring technology through a combination of centralized. The key technology of this solution is that the monitoring point selection. Refining process equipment corrosion occurs mainly divided into two categories, namely high-temperature chemical corrosion and sulfide, H_2S/HCl low-temperature electrochemical corrosion. The former mainly for uniform corrosion; the latter mainly both general corrosion, pitting, pitting, and sulfide stress corrosion cracking. Therefore, the process should be based on means, corrosion distribution process corrosion, corrosion characteristics of phase transition zone materials for high-temperature equipment selected points. According to the principles of corrosion and design experience, high-sulfur refining apparatus above 260 °C began to focus on monitoring; high acid crude oil refining unit focused on monitoring more than 230 °C.

On-line corrosion monitoring process, the probe often appear abnormal, there are two forms: one is the measurement value remains unchanged, the second is volatility measurement. In eliminating the outside interference issues, from the following aspects to solve: pH probe anomaly mostly because of the condensed water contains large amounts of hydrogen sulfide, because the structure of the probe tip is a glass semipermeable membrane, and the electrode is

Ag/AgCl composition when there is pressure, so that the electrode prematurely damaged. An electrode can be used to exit protection---probe cleaning solution to the problem of pollution.

4.2 In the Application of Circulating Cooling Water System

A new on-line corrosion monitoring technology - coupled multi-electrode array sensor technology[9]. It works by dividing the metal surface into small enough parts, each part independently of each other, and through an external circuit with a wire to these separate portions coupled together to form a path, anode and cathode metal corrosion reaction so they will have simulated corrosion generated electrons will flow through an external circuit coupled to the cathode from the anode, the metal localized corrosion rate can be obtained by measuring the external current (cross-sectional area of each small part is known) [10], and the tow electrodes similar to each electrode and the public coupled between nodes are connected via a resistor from galvanic corrosion electrode outflow produce a small pressure drop. At the time through a resistor, each resistor voltage drop by high sensitivity voltmeter measured ratio of the multi-channel voltage and resistance is current [11-12].

Coupled multielectrode array sensor in the cooling water system chemical cleaning process, having a chemical cleaning effect, the results showed that the corrosion monitoring data is consistent with the coupon monitoring data, to cleaning quality standards, it is an important means of line corrosion monitoring.

4.3 The Application of the Ground Production System in the Gas Field

The coupon method and the resistance method for the corrosion monitoring system of gas production, according to the principles of construction of corrosion monitoring points, in covering wellheads [13], separators, gas gathering pipelines, pressurized dewatering device, and gathering trunk entire system is performed corrosion monitoring.[14] The surveillance monitoring period is carried out once every 30 days; a resistance probe line monitoring device is required every three months for a data collection, we need to monitor a specific area from time to time according to the actual production.

Coupon method and resistance method, although the method is to point to an area of, it can be a timely and effective manner to reflect the situation in the short term pipeline corrosion. Therefore, according to the results, analysis corrosion change, propose targeted anti-corrosive recommendations.

4.4 The Application of in Atmospheric and Vacuum Distillation Unit

Use of line corrosion detection system ten sets low inductance probe, six sets temperature probe, and three sets inductance probe pH value. Detection site in the initial boiling systems, atmospheric systems, and depressurization systems. Through the atmospheric and vacuum distillation curve line corrosion monitoring system and real-time monitoring of oil quality analysis showed that the two are consistent. The on-line corrosion monitoring system can effectively monitor the corrosion of plant equipment, according to abnormal changes in corrosion curve, timely adjustment and crude oil blending ratio of atmospheric and vacuum distillation plant process parameter adjustment, effective mitigation device equipment corrosion, corrosion of equipment play a preventive role [15].

4.5 In the Application of High Sulfur Gas Purification Plant

The purification plant for the purification process characteristics: using DG-9500 probe at each joint desulphurization, dehydration, sulfur recovery, tail gas treatment, acid water stripping unit arranged a total of 14 sites as corrosion monitoring. By one year of corrosion monitoring, out of the extent of corrosion of each process node, and combining the results of corrosion coupon, identify the presence of high-sulfur natural gas purification plant corrosion weaknesses. The results show that corrosion rule: line corrosion monitoring and corrosion

resulting corrosion rate coupon consistent, description Online monitoring tools can be effectively used for monitoring the status of high-sulfur purification plant corrosion. Research results for the high-sulfur purification plant provide an important basis for corrosion control [16].

4.6 Application in the Catalytic Cracking Unit

The contrast experiments of on-line corrosion monitoring systems were carried out between the DG-5300A of inductance probe on-line corrosion monitoring system, manufactured in China, and the MK-9300 of portable one, made in the USA. Determining the location of corrosion monitoring: low-temperature stable parts of the absorption Overhead Air Cooler, import and export water coolers, high-temperature parts of the device sideline, fractionation bottoms pipeline, and Fractionation tower bottom line heat exchange area. The results showed that the sensitivity in the two systems on metal corrosion was equal [17].

4.7 Application in Offshore Platform

Comprehensive Selection line corrosion monitoring technology, monitoring should focus on localized corrosion point position: as the platform riser, chemical injection point downstream; wellhead flow lines (chemical injection point downstream); import stage separator and the test separator; each level of the water separator outlet line; each level is separated from the gas export pipeline; gas export pipeline cooler waters; sorter flotation gas scrubber outlet line; downstream water injection system degassing; closed drainage system, etc.

Adopt effective corrosion monitoring technology not only as a judge the extent of corrosion damage, to determine the appropriate anti-corrosion measures and provide the appropriate tools solutions, can also monitor the effectiveness of anti-corrosion measures, provide production technology or management data, constitute part of the automatic control system [18].

5. Conclusion

Corrosion problems of increasingly serious, therefore line corrosion monitoring technology more and more people's attention. It has the following main development direction:

- (1) Enhanced corrosion monitoring instrument sensitivity, prolong the life of the probe, reduce monitoring costs;
- (2) According to the principles of safety and economy. A new method developed probes installed, reducing the impact of the probe installed on the original production equipment reliability;
- (3) Development of new corrosion monitoring equipment, improve the accuracy of online corrosion monitoring techniques;
- (4) The integrated use of line corrosion monitoring technology, a wide range of monitoring corrosion processes, corrosion mechanism of intelligent judgment.

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